5G Wireless Technology Overview

Emerging Trends Committee
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Agenda

- What is 5G Wireless? Karen Eckersley
- What does 5G Wireless look like? Rob Osborn

Mobile Wireless Networks - Evolution

1G

1980's

Basic analogue voice
No IP

0 kbit/s

One network for voice

NMT, AMPS, TACS

2G GSM

1990's

Digital voice
No IP

14kbps

One network for voice

GSM, IS-95
2.5G (GPRS, EDGE)

3G UMTS

2000's

Digital voice
WWW, multimedia

2Mbps

One network for voice
Other network for IP

UMTS, CDMA2000
3.5G (HSDPA, HSUPA, HSPA+, LTE)

4G LTE

2010's

Voice over IP
HD Video

300Mbps

One network for IP

LTE-Advanced
4.5G (LTE-Advanced Pro)

5G 5G

2020's

Voice over IP
VR, V2X, IoT

1Gbps

One network for IP

LTE-Advanced Pro
NR

GRANDMETRIC
NETWORK & WIRELESS... STAY CONNECTED

What Is 5G?

5G is an umbrella term for a set of international wireless standards

eMBB

Enhanced Mobile Broadband

Super fast broadband with speed and capacity
Up to 100x faster speeds than 4G

- Download full-length HD movie in seconds
- Stream 4k video
- Home internet

Massive Machine Type

Internet of Things for Everything

Super cheap connectivity for millions of devices

- Transmits low volume of non-delay-sensitive data
- Low bandwidth
- Low cost devices with extremely long battery lives

URLLC

Internet of Things for Infrastructure

Ultra-reliable, resilient and instantaneous connectivity with strict requirements on availability, low delay, and speed

- Automated vehicles
- Industrial controls for manufacturing
- Remote medical surgery
- Distribution and automation on a smart grid

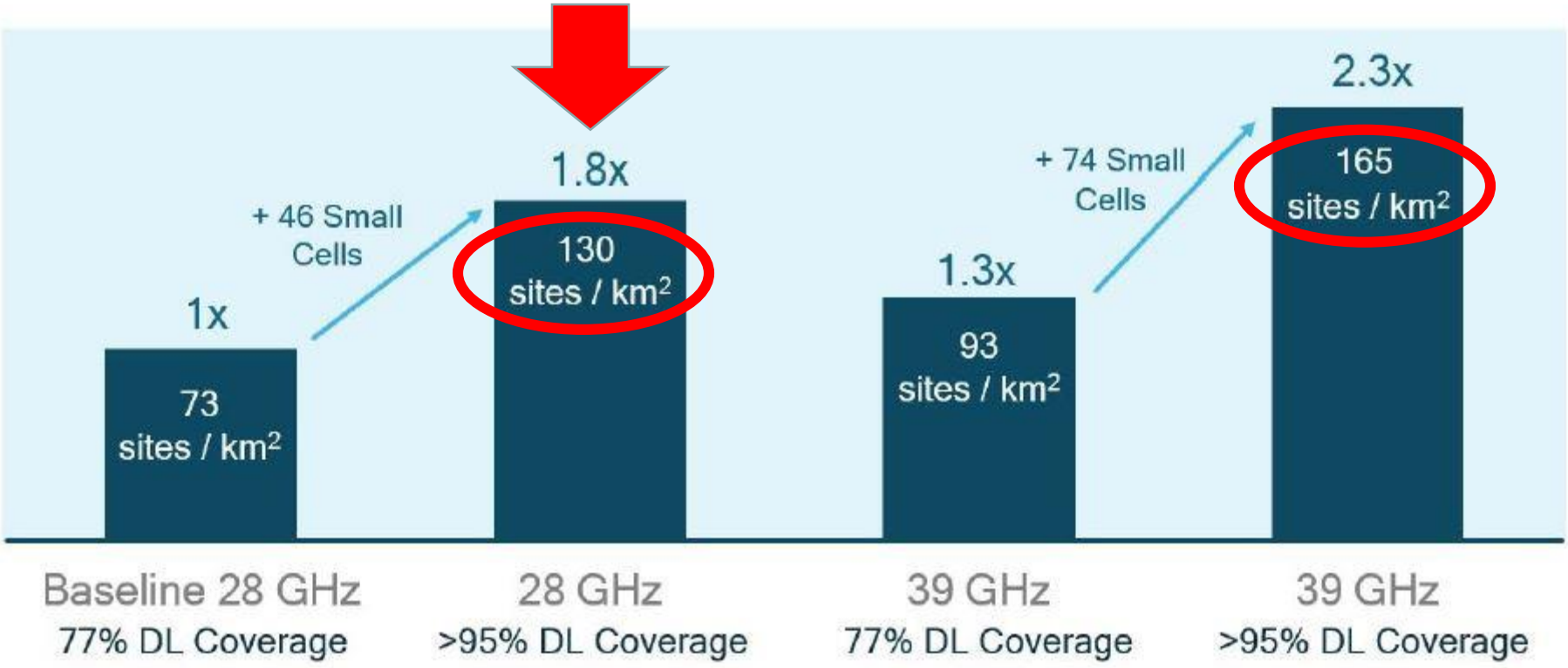
5G Uses Defined by Spectrum

Higher frequency spectrum requires more cell sites per square mile

- **Coverage** of large areas at 600 and 800 (some 900) MHz
  - Looks like cellular, only without some interference issues that come at higher frequencies
  - Several miles of coverage
  - Perfect for rural areas, non-line of sight locations
- **Capacity** for many users at 2.5, 3.5, 3.7-4.2 GHz
  - Good for suburban and rural deployments, BUT requires line of sight
    - You must be able to see directly from the antenna to the end device
    - Fixed wireless looks promising
- **Fiber-like speeds** at mmWave at 28 and 39 GHz
  - Areas of 150-200 meter coverage
  - Good for urban areas, BUT it requires line of sight

Getting to 95% Coverage with mmWave:

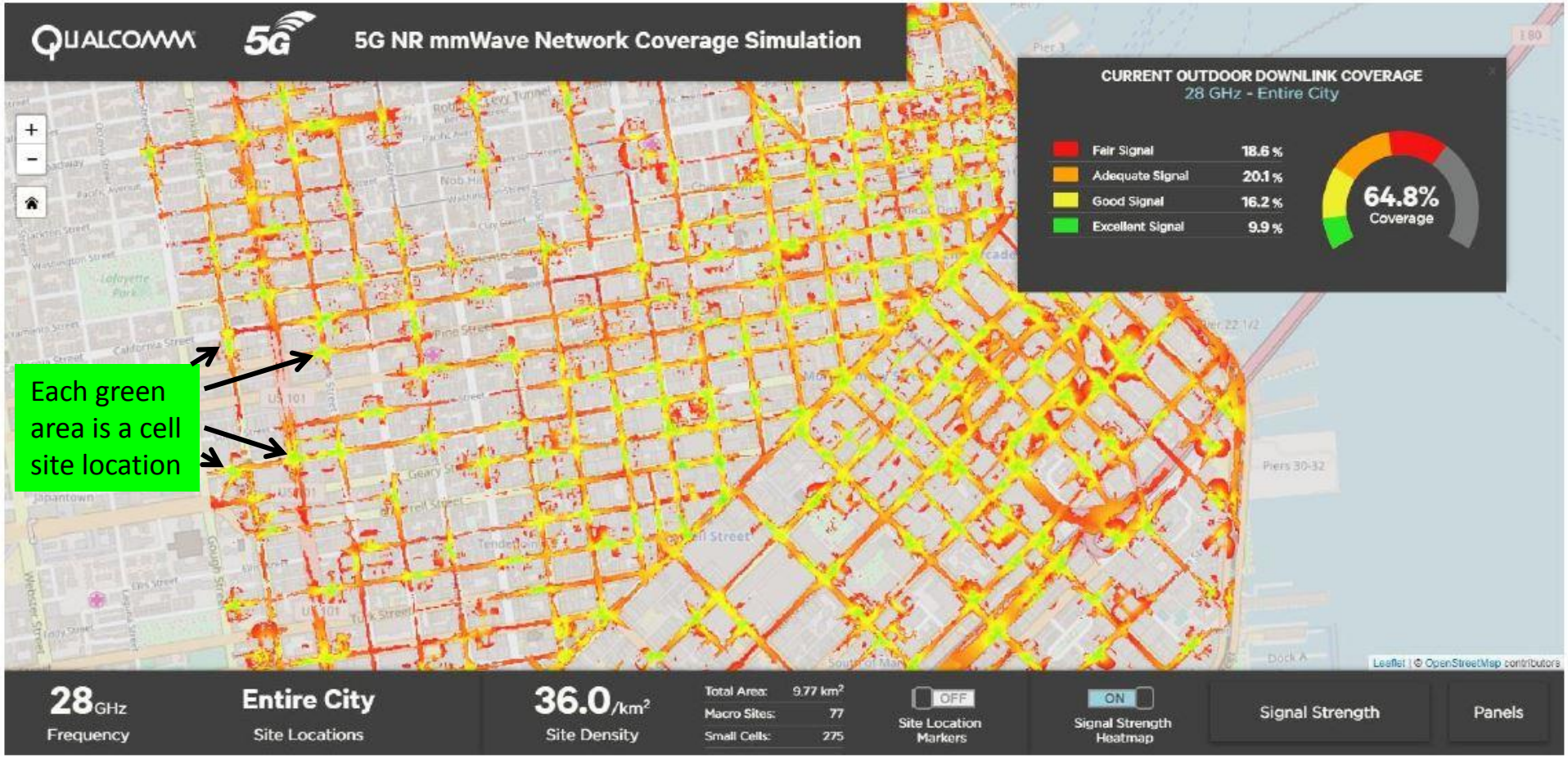
Increasing the number of cell sites to 130 per square kilometer for 28 GHz would give 95% downlink coverage; for 39 GHz, 165 sites per sq. km is needed.



Source: “Mobilizing 5G NR Millimeter Wave: Network Coverage Simulation Studies for Global Cities,” Qualcomm, October 2017

Signal strength map for San Francisco (green is strong)

5G NR mmWave coverage using 28GHz: 36 sites/sq. Km = **64.8% coverage**



- Red is 40 mbps average downlink speed using 100 MHz of spectrum
- Green is 500 mbps average downlink speed using 100 MHz of spectrum
- Site spacing equates to 167 meters between sites based on a site density 36 per square kilometer.
- Coverage shown is outdoor street level (no indoor coverage)

Source: "Mobilizing 5G NR Millimeter Wave: Network Coverage Simulation Studies for Global Cities," Qualcomm, October 2017

Thank you!
For Additional Information:

www.cpuc.ca.gov